

5 E Lesson Design: It's Greek to Me

Robin Bucaria, Dartmouth Middle School
Dr. Brad Bebout, NASA Ames Research Center

Abstract

“It’s Greek to Me” focuses on reading strategies to help students comprehend difficult text. Given a scientific article on microbial mats, students will explore ways to make meaning of a text, explain how they reached the conclusions they did and apply these strategies to other reading experiences. Reading strategies include applying grammar and context clues to further comprehension, using knowledge of Greek and Latin prefixes, suffixes, and roots to break down unfamiliar words and determine their meaning, retelling and other methods to help determine meaning.



A scientific paper by Bebout, et al. The entire paper is contained in the file: Bebout_et_al_2002.pdf

Overview of 5 E Lesson Design

Engage

(Pick the engage activity or activities that best meets the needs of the class, but make certain to use the pretest of words used in the Bebout et al. article before beginning the explore activities.)

- **Brainstorm:** What do you do when you have a difficult text to read?
- **Gibberish passage**
- **Translate a “teen speak” Passage:** What do you need to do to understand it if you are not a teen?
- **Movie clip from “My Big Fat Greek Wedding”** illustrating knowledge of Greek roots
- **Pretest of words used in Bebout, Brad M. et al. (2002), Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth’s Present and Past Field Environments, Astrobiology 2, 383-402.**
- **Prefix, suffix, root “dissection”**
- **Invent a new word with prefixes, suffixes or roots: Sniglet concept**

Explore

- **Model Think-Aloud Strategies**
- **Apply Think-Aloud Strategies: Pair/Share Activities**
 - What strategies can you use to make sense of the passage?
 - What other strategies can you think of that would help make the passage comprehensible? (Document the Process)
 - Make a chart or table that evaluates the strong and weak points of each reading strategy used—comparison with other student team

Explain

- **Students explain Pair/Share**
 - Process
 - Strategies
 - Present best method and show how it works

Extend

- Retelling as a tool for textual comprehension
- Rewrite Introduction of Bebout, Brad M. et al. (2002), Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments, Astrobiology 2, 383-402. in a different Genre

Evaluate

- Scoring Rubrics
- Post-Test

Engage

Brainstorm

1. Present the following scenario for students brainstorming and discussion: You have just been given a text to read. You look at the words on the page. You can say them—but the text that you are reading might as well be written in Greek. The words have no meaning for you. The text is important for you to read and understand. What are you going to do about it?
2. Break the class into groups of no more than five students for the Brainstorming activity. Give each group chart paper to write down their responses and present the following question for Brainstorming: What do you do (or what can you do) when you have a difficult text to read?
3. Large cards labeled: “Producers”, “Consumers” and “Decomposers”.
4. Have the group pick their two best ideas and give an example for each idea.
5. Have the group nominate a reporter for the group to share the ideas with the class.
6. In a full class discussion, have groups share the strategies and examples that they created for dealing with a difficult text. Make a class list of strategies to use on chart paper. Post these strategies in the classroom.

Gibberish Passage

Handout: The Monotillation of Traxoline by Judy Lanier

1. Present the gibberish passage, The Monotillation of Traxoline by Judy Lanier, to the class. Have them answer the questions at the bottom of the passage.
2. Discuss student answers to the questions.
 - a. **How were they able to answer the questions?**

Answer: Answers will vary. Possible answers include using the words in the passage that are located around the word(s) mentioned in the question to offer a response.
 - b. **Even though they can answer the questions, what is the problem with their answers?**

Answer: Even though they can tell you the answers to the questions, the answers have no meaning because they do not know the words.
 - c. **If this was a passage with real words, what strategies could you use to help determine the meaning?**

Answer: The words around the unknown word could help build meaning (context clues). A dictionary could be used to discover the meaning of unknown words.

3. Make certain that students arrive at the conclusion that even though one can use context clues to answer questions, if there is no understanding of the words or concepts that answer the question, the passage makes no sense. If a reader does not comprehend the passage, reading is not occurring. Reading is not decoding, or pronouncing the words on the page; it is a meaning-making process.

Translate a “teen speak” Passage

1. Have pairs of students in each class write a passage using teenage slang. Collect the passages and review them for class the next day.
2. Exchange teen speak passages between classes or students.
3. Have each student group read the passage and decide what a reader would need to understand if he or she did not know this slang.
4. Have each group record their teen speak comprehension hints.
5. Have each group present one strategy to the class.
6. Have a student record these strategies on the board.

Movie Clip

Materials: Clip from “My Big Fat Greek Wedding”

1. Show a selection from “My Big Fat Greek Wedding” that illustrates how prefixes and suffixes and roots can be used to break down words.
3. Discuss how prefixes, suffixes and roots can be used to determine word meaning.

Pretest of reading words used in Science Article

Handouts: Pretest of Words used in Bebout et al. Article Key for Pretest of Words used in Bebout et al. Article

Materials: Clip from “My Big Fat Greek Wedding”

1. Give students a pre-test of unfamiliar words or words used in a different way in an article.
3. 2) Collect the pre-test, score it as a class and demonstrate the need for using strategies to determine the meaning of the text, which contains material that is difficult to understand.

Prefix, suffix and root “dissection”

Handouts: Prefix, Suffixes and Roots for English Unit Prefixes, Suffixes and Roots for English Unit Teacher Reference Words for Dissection

Meathods:

1. Break students into groups of two.
2. Pass out the Greek and Latin Prefixes, Suffixes and Roots handout to use to determine the meaning of unknown words.
3. Give each group a word to dissect using Greek and Latin Prefixes, Suffixes and Roots to determine word meaning.
4. Have students determine the meaning of the word by combining the meaning of the prefixes, suffixes and roots.
5. Students need to pick their best word to display on a poster a present to the class.

Explore

Model Think-Aloud Strategies

Think aloud reading strategy workshop using text from Science Article: Bebout, Brad M. et al. (2002), Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments, *Astrobiology* 2, 383-402.

Introduction

One of the best ways to teach reading comprehension is to model the strategies that a good reader uses to make sense of an unfamiliar text. The purpose of a think aloud is for the teacher to take an unfamiliar passage of a difficult text and talk aloud, giving the students a dialogue of what happens inside the brain when reading. Another purpose is to demonstrate the strategies the teacher uses to make sense of a text. In this exercise, semantic and syntactic context clues will be used to determine the meaning of the text. Semantic context clues are those that help to determine meaning, such as using definition, synonyms, antonym, examples, explanation, experience or knowledge of a subject to understand the words in a text. Syntactic context clues give grammatical information, such as part of speech, or origin information, such as prefix, suffixes, and roots.

Main Concept

Students will apply reading strategies such as using context clues, grammatical structures, punctuation and Greek and Latin prefixes, suffixes, and roots to determine the meaning of a difficult text.

Question: *What strategies can be used to understand a difficult text?*

Objectives:

1. The student will apply knowledge of Greek and Latin affixes to determine the meaning of words in the article.**3.**
Large cards labeled: "Producers", "Consumers" and "Decomposers".
2. The student will apply knowledge of grammatical structures and punctuation rules to determine the meaning of words in an article.
3. The student will use context clues (definition, synonyms, antonym, example, explanation, experience or knowledge of a subject) to determine the meaning of the text.
4. The student will look for multiple meanings of words and apply the correct meaning to understand text.
5. The student will discover through reading how living organisms affect the composition of the atmosphere.
6. The student will learn how organisms in microbial mats function as ecosystems exchanging nutrients among themselves and with the environment.

National Standards

IRA/NCTE Standards for the English Language Arts (NLAS)

National Science Education Standards (NSES)

Fully Met	Partially Met	Addressed
<p>NLAS #3: Apply strategies to comprehend, interpret, evaluate, and appreciate texts</p> <p>NLAS #4: Adjust use of language to communicate effectively</p> <p>NLAS #6: Apply knowledge of language to create, critique, and discuss print and non-print texts.</p>	<p>NLAS #1: Read range of print and non-print texts</p> <p>NLAS #8: Use technological and information resources to gather and synthesize information and create and communicate knowledge</p> <p>NSES C4(5-8): Structure and Function in Living Systems a</p> <p>NSES C6(5-8): Regulation and Behavior a, c, d</p> <p>NSES C7(5-8): Populations and Ecosystems a, b, c, d</p> <p>NSES C8(5-8): Diversity and Adaptations of Organisms b</p> <p>NSES D4(5-8): Structure of the Earth System k</p>	
	<p>2061: 5A(6-8) #1, #5</p> <p>2061: 5D(6-8) #1, #2</p> <p>2061: 5E(6-8) #1, #2, #3</p> <p>2061: 11A(6-8) #1,</p> <p>2061: 11C(6-8) #1,</p>	

California Education Standards

Fully Met	Partially Met	Addressed
<p>LA Grade 6: Reading 1.0</p> <p>LA Grade 6: Vocabulary & Concept Development 1.4</p> <p>LA Grade 7: Reading 1.0, 1.2, 1.3</p> <p>LA Grade 8: Reading 1.0</p> <p>LA Grade 8: Vocabulary & Concept Development 1.3</p> <p>Science Grade 6: Ecology #5 a, b</p>	<p>Science Grade 8: Chemistry of Living Systems #6 b</p> <p>Biology/Life Sciences Grade 9-12: Ecology #6 c</p> <p>Earth Sciences: Biogeochemical Cycles Grades 9-12 #7 a, #8 b</p>	<p>Science Grade 8: Chemistry of Living Systems #6 a</p>

Abstract of Lesson

This lesson models comprehension strategies to use with a scientific text and then has students apply these strategies to their own reading.

Prerequisite Concepts

1. Words are formed using prefixes and suffixes and roots that have meaning from Greek and Latin.

Major Concepts

1. Knowledge of Greek and Latin affixes can be used to figure out the meaning of a difficult word.
2. Sentence syntax, punctuation and grammar can be used to figure out the meaning of word in a sentence.
3. Context clues such as definition, synonym, antonym, examples, explanation, experience, and knowledge of subject can be used to determine meaning.
4. Definition substitution and context clues can help establish the meaning of words that have multiple meanings.
5. Living organisms in microbial mats affected the composition of the atmosphere.
6. Organisms in microbial mats are self-sustaining ecosystems exchanging nutrients among themselves and with the environment.

Misconceptions

1. Nothing can be done to aid comprehension when a text is difficult to understand.
2. If words are unfamiliar or difficult to understand, they can be ignored when reading.

Materials

1. Overhead transparencies of a clean copies of the passages from Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments.
2. Copies of the passages from Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments for the class.
3. A marked sample of a teacher think aloud to use as a model for the classroom teacher's preparation of this strategy. There are different copies that are marked for the different strategies that the students are using. Examples are taken from the pretest. Note that it is better if you document your thinking process on the clean copy of the text for your students. This is included as a guide for preparation if the strategy is unfamiliar.
4. Copies of other passages from Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments to use with the class for paired practice after teacher modeling of strategies.

Methods

1. Have students complete the reading pretest to determine which strategy to model in your Think-Aloud.
2. Score the Reading Pretests. The strategies that are covered by each section are:
 - **Syntactic Context Clues using Grammar** (A grammar or punctuation rule helps determine word meaning): Questions 1 and 8
 - **Multiple Meanings and Context Clues** (Context clues, the words, phrases or sentences around an unfamiliar word, help to determine the meaning of a word that has multiple meanings.): Question 4
 - **Prefixes, Suffixes, and Roots** (A knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions: 2 and 5
 - **Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots** (A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10
 - **Semantic Context Clues** (The words, phrases or sentences around an unfamiliar word that help determine its meaning.): Question 7 and 9
3. Divide students into strategy study groups based on the section where the student missed the most questions. In the strategy workshops, it is easier to apply one strategy at a time. If a student misses an equal number of questions in several sections, it would be best to start the student in one of the following sections where he or she has missed questions:
 - Semantic Context Clues
 - Prefix, Suffixes, and Roots
 - Syntactic Context Clues using Grammar.

The strategy workshops where strategies will be combined are more difficult:

- Multiple Meanings and Context Clues
- Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots.

After reviewing the pretests, divide your class into groups to model the strategy that each student needs the most practice using. If strategies are modeled at one time, students will become confused. Therefore, divide the class into groups, model one strategy and allow for practice and application time. If students have trouble applying several strategies the other strategies can be modeled latter in the year after students have a chance to master the application of one strategy.

4. Depending on the number of groups, prepare alternative activities for the group members who are not involved in the Think-Aloud strategy instruction group. This is a good time for independent reading.
5. For each group, place a copy of the selected passage from Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments on the overhead and pass out copies to students. Make certain that you select the model for the strategy instruction that you are modeling.
6. When reading, mark the passage with questions, comments, and the thinking process used to make sense of an unfamiliar text. Have students mark your thinking strategies on their handouts. (If comments are made on clear overhead arrows that you tape to the overhead, the comments can be removed and rearranged to use when writing a summary. A master of large overhead arrows can be made by using a word processing program to create the master and then by copying the master on overhead transparency film using the copy machine.)

7. As unfamiliar terms come up use the strategy you are modeling (context clues, a knowledge of prefixes, suffixes and roots, and reference materials such as dictionaries and/or the internet) to make sense of the material. Have students look up unfamiliar terms and share them with the class. Add them to your mark-up of the passage.
8. Discuss the methods used and any other questions about strategies that the students might have.
9. Select other passages from the text to have students read in pairs. In this paired reading, students practice the strategy, marking the article with comments post-it-notes that can be later removed to organize the material for summary writing.
10. Apply think-pair-share strategies.

Explain

Have students take the introduction to the Bebout et al. article and rewrite it in a different genre. Models are included in the handouts that can be made into overhead transparencies.

Extend

Use retelling to aid in comprehension of a text.

Methods:

1. Have students take the introduction to the Bebout et al. article and rewrite it in a different genre. Models are included in the handouts that can be made into overhead transparencies.
 - Model the Rephrasing Activity for Narrative Retelling with the passage from Bucaria, R. and Bebout B. A Teacher's Guide to Stromatolite Explorer. Microbes @ NASA. <http://microbes.arc.nasa.gov> p.9
 - a. Read the passage as a class.
 - b. Highlight the main ideas of the passage.
 - c. Rephrase main ideas in your own words.
 - d. Number the ideas in the order you want to write about them.
 - e. Select the type of narrative retelling for writing.
 - i. Narrative: write a fictional story written from the bacteria's perspective on life in a microbial mat.

Narrative structure includes:

 - Hook
 - Description
 - Dramatic detail
 - Voice
 - First person (bacteria) narration
 - Plot: introduction (character, setting, etc.), inciting incident, rising action, climax, denouement, and resolution
 - i. Picture Book: write a children's story using the same structure as the original picture book text. For example, use Cynthia Rylant's *When I was Young in the Mountains*, Bill Martin Jr.'s *Brown Bear, Brown Bear, What do you see?*, Dr. Seuss' books, etc. and follow the patterns, sentence structure, rhythm and style using content from the article you are retelling.

Picture Book structure includes:

- Same structure and rhythm as the original picture book text.
- Repetition of words, phrases, or images
- Words help reader picture ideas

- ii.** Poem: write a poem using images, word choice, line breaks, flow or rhythm to convey the information in the article.

Poetry structure includes:

- Vivid words and images used to convey ideas
- Succinct language
- Link breaks used to emphasize meaning.
- Flow or rhythm draws readers into the poem

- b.** Review the Narrative Retelling Rubric when planning the rewrite to make certain that all criteria are addressed in the retelling.
- c.** Write the narrative.

Evaluate

Scoring Rubrics

- Narrative Retelling Rubric with Content from Bebout Article
- Narrative Retelling Rubric (master)

Pretest

- Pretest of words used in Bebout Article

Posttest

- Posttest of words used in Bebout Article

List of Models and Handouts (That follow this page.)

Gibberish Passage: The Monotillation of Traxoline

KEY: The Monotillation of Traxoline

Pretest of words used in Bebout Article

KEY: Pretest of words used in Bebout Article

Prefixes, Suffixes and Roots

Words to use for Prefix, Suffix, and Root Dissection

Prefixes, Suffixes and Roots with Related Science Words

Unmarked Think-Aloud: Syntactic Context Clues using Grammar(Questions 1 and 8 from Pretest)

Marked Think-Aloud: Syntactic Context Clues using Grammar(Questions 1 and 8 from Pretest)

Unmarked Think-Aloud: Multiple Meanings and Context Clues (Question 4 from Pretest)

Marked Think-Aloud: Multiple Meanings and Context Clues (Question 4 from Pretest)

Unmarked Think-Aloud: Prefixes, Suffixes, and Roots (Questions 2 and 5 from Pretest)

Marked Think-Aloud: Prefixes, Suffixes, and Roots (Questions 2 and 5 from Pretest)

Unmarked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes and Roots (Questions 3, 6, and 10 from Pretest)

Marked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes and Roots (Questions 3, 6, and 10 from Pretest)

Unmarked Think-Aloud: Semantic Context Clues (Questions 7 and 9)

Marked Think-Aloud: Semantic Context Clues (Questions 7 and 9)

Unmarked Paragraph from Bebout Article: Introduction

Marked Paragraph from Bebout Article: Introduction: Prefixes, Suffixes and Roots (marked using comment feature)

Marked Paragraph from Bebout Article: Introduction: Syntactic Context Clues using Grammar and Prefixes, Suffixes and Roots (marked using comment feature)

Marked Paragraph from Bebout Article: Introduction: Semantic Context Clues (need to marked using comment feature)

Unmarked Think-Pair-Share: Syntactic Context Clues using Grammar

Marked Think-Pair-Share: Syntactic Context Clues using Grammar

Unmarked Think-Pair-Share: Multiple Meanings and Context Clues

Marked Think-Pair-Share: Multiple Meanings and Context Clues

Unmarked Think-Pair-Share: Prefixes, Suffixes, and Roots

Marked Think-Pair-Share: Prefixes, Suffixes, and Roots

Unmarked Think-Pair-Share: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

Marked Think-Pair-Share: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

Unmarked Think-Pair-Share: Semantic Context Clues

Marked Think-Pair-Share: Semantic Context Clues

Posttest of words used in Bebout, Brad M. et al. Article

Key for Posttest of words used in Bebout, Brad M. et al. Article

Unmarked Narrative Retelling Model from A Teacher's Guide to Stromatolite Explorer

Unmarked Narrative Retelling Model from A Teacher's Guide to Stromatolite Explorer: Find the main ideas in the paragraph

Marked Narrative Retelling Model from A Teacher's Guide to Stromatolite Explorer: Find the main ideas in the paragraph

Rephrasing Activity for Narrative Retelling with text

Rephrasing Activity for Narrative Retelling with text and rephrasing

Introductory Paragraph to use with Narrative Retelling (for independent practice)

Rephrasing Activity for Narrative Retelling (blank)

Narrative Retelling Rubric with Content from Bebout Article

Narrative Retelling Rubric (master)

Directions: Read the following passage and answer the questions below in complete sentences.

The Monotillation of Traxoline

By Judy Lanier

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is monotilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then bracter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lesceledge.

What is traxoline?

Where is traxoline monotilled?

How is traxoline quaselled?

Why is it important to know about traxoline?

KEY

The Monotillation of Traxoline

By Judy Lanier

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is monotilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then bracter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lescelidge.

What is traxoline?

Traxoline is a new form of zionter.

Where is traxoline monotilled?

Traxoline is monotilled in Ceristanna.

How is traxoline quaselled?

First, large amounts of fevon is gristerlated. Next, the gristerlated fevon is bractered to quasel traxoline.

Why is it important to know about traxoline?

It is important to know about traxoline because it may well be one of our most lukized snezlaus in the future because of our zionter lescelidge.

- A. to make smaller**
- B. rock-like layers of sand or minerals produced by microorganisms trapping, binding or precipitating sediment**
- C. in a new position**
- D. the addition of oxygen to a physical system**
- E. unstable salt concentration**
- F. to remove oxygen from a substance**
- G. able to change position**
- H. existing without oxygen**
- I. the pigment change caused by certain microorganisms moving to the top of a mat**
- J. in the original position**
- K. the gases that surround the earth**
- L. able to obtain energy from light**
- M. high salt concentration**
- N. the solid part of the earth known as the crust and the mantle**
- Match the highlighted words in each passage on the left, with the letter of the correct definition located at the top of the page. Underline the words or parts that give a clue to the meaning of the bold word in the sentence.
- _____1. Geochemical evidence of the existence of photosynthetic microbial mats, and their mineralized counterparts, stromatolites, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989) (page 384). (Ga= billion years ago)
- _____2. Because these microbial mats are considered to be useful analogs of ancient marine communities, they offer insights about evolutionary events during the >3 billion year time interval wherein mats co-evolved with Earth's lithosphere and atmosphere (page 383).
- _____3. To understand the overall structure and function of mat communities, it is thus critical to determine the nature and extent of the interactions between phototrophic and non-photosynthetic microorganisms, including anaerobic microorganisms (page 384).
- _____4. When oxygenic photosynthesis ceases at night, the upper layers of the mat become highly reduced and sulfidic (Jørgensen et al., 1979) (page 384).
- _____5. Photosynthetic microbial mat communities were obtained from marine hypersaline saltern ponds, maintained in a greenhouse facility, and examined for the effects of salinity variations (page 383).
- _____6. As dominant components of our biosphere for at least 2 billion years of its >3.5 billion year history, microbial mats played a pivotal role in shaping the composition of Earth's early atmosphere, including its eventual oxygenation (page 385).
- _____7. Normal in situ daily water column temperature variations were simulated in the greenhouse by (1) controlling the temperature increase (attributable to solar heating) during the daytime to stay below the maximum temperature observed in situ and (2) turning off temperature control at night to allow the water temperature in the flow boxes to decrease slowly with the decrease in greenhouse air temperature (page 387).
- _____8. In particular, no evidence of the mat "greening," in which motile cyanobacteria migrate to the surface of the mat (Bebout and Garcia-Pichel, 1995), was apparent (page 390).
- _____9. Furthermore, many mat microorganisms are motile, utilizing light and /or UV radiation as a cue to adjust their position in the mats vertically (Castenholz, 1994; Bebout and Garcia-Pichel, 1995) (page 398).
- _____10. In this way, exposure of the deeper anaerobic layers of the mats to air and light was minimized (page 385).

KEY

- A. to make smaller**
- B. rock-like layers of sand or minerals produced by microorganisms trapping, binding or precipitating sediment**
- C. in a new position**
- D. the addition of oxygen to a physical system**
- E. unstable salt concentration**
- F. to remove oxygen from a substance**
- G. able to change position**
- H. existing without oxygen**
- I. the pigment change caused by certain microorganisms moving to the top of a mat**
- J. in the original position**
- K. the gases that surround the earth**
- L. able to obtain energy from light**
- M. high salt concentration**
- N. the solid part of the earth known as the crust and the mantle**
- B** 1. Geochemical evidence of the existence of photosynthetic **microbial mats**, and their **mineralized** counterparts, **stromatolites**, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989) (page 384). (Ga= billion years ago) *The word stromatolites is defined by grammar and context clues. The definition photosynthetic microbial mats, and their mineralized counterparts is given before the commas setting off the appositive containing the word, stromatolites, which has just been defined. Words are often set off by commas for emphasis or definition.*
- N** 2. Because these microbial mats are considered to be useful analogs of ancient marine communities, they offer insights about evolutionary events during the >3 billion year time interval wherein mats co-evolved with Earth's **lithosphere** and atmosphere (page 383). *Breaking the word, lithosphere, into parts helps determine its meaning. Litho is a Greek prefix meaning stone, sphere means round. Literally, the lithosphere is the stone sphere around the earth or the earth's crust and mantle.*
- L** 3. To understand the overall structure and function of mat communities, it is thus critical to determine the nature and extent of the **interactions between phototrophic and non-photosynthetic microorganisms**, including anaerobic microorganisms (page 384). *The meaning of the word phototrophic can be determined through a combination of grammatical context clues and a study of prefixes, suffixes and roots. The grammatical structure, interactions between phototrophic and non-photosynthetic microorganisms, implies a contrast between microorganisms that are phototrophic and those that are non-photosynthetic. It can be inferred that phototrophic organisms are photosynthetic, since there is an interaction between those organisms that are phototrophic and those that are non-photosynthetic. A study of the word parts confirms this guess from context clues. Photo is a Greek prefix that means light. Troph is a Greek root means nourishment. The affix, ic, is Middle English suffix which means relating to. If a phototroph is a microorganism that relates to getting nourishment from light, then a phototrophic organism is photosynthetic and able to obtain energy through light.*
- F** 4. When **oxygenic photosynthesis ceases** at night, the **upper layers** of the mat become highly reduced and sulfidic (Jørgensen et al., 1979) (page 384). *This is an example of a word, reduced, that has multiple meanings and may be used in an unfamiliar way. The context clues in the sentence show that the common definition, to make smaller, is not the best one, because reduced is linked with the word sulfidic through the use of "and". Earlier in the sentence, the statement is made, "When oxygenic photosynthesis ceases..." providing the clue that removing oxygen from a substance would be the correct definition.*
- M** 5. Photosynthetic microbial mat communities were obtained from marine **hypersaline** saltern ponds, maintained in a greenhouse facility, and examined for the effects of salinity variations (page 383). *Break down each of the word parts to find the meaning of this word: hyper is a Greek prefix used before nouns and adjectives meaning excessive, overly, too much, or unusual. The word part, sal is Latin for salt and ine is a Latin suffix meaning of or relating to. Hypersaline would mean excessively salty.*
- D** 6. As dominant components of our biosphere for at least 2 billion years of its >3.5 billion year history, microbial mats played a pivotal role in shaping the composition of Earth's early **atmosphere**, including its eventual **oxygenation** (page 385). *Context clues and word part analysis help one to determine the meaning of this word. If one knows that the atmosphere is composed of oxygen and other gasses, then one can guess that oxygenation has something to do with oxygen. When one looks at the word parts, one finds that the oxy or ox-prefix means oxygen, gen is a Greek root meaning origin or source, and ion is a suffix which means condition or action. Put it together and one has the condition or action of the origination of oxygen.*

J 7. **Normal** in situ **daily** water column temperature variations **were** simulated in the greenhouse by (1) controlling the temperature increase (attributable to solar heating) during the daytime **to stay below the maximum temperature observed in situ** and (2) turning off temperature control at night to allow the water temperature in the flow boxes to decrease slowly with the decrease in greenhouse air temperature (page 387). *The context clues, normal, daily, were simulated in the greenhouse, as well as, to stay below the maximum temperature observed in situ indicate that in situ would be the opposite of conditions in the greenhouse, or the conditions in the natural environment. Also the italics indicate that it is another language, Latin in this case, from the web "Latin for 'in original place.' Refers to measurements made at the actual location of the object or material measured."*

I 8. In particular, no evidence of the mat "greening," **in which motile cyanobacteria migrate to the surface of the mat** (Bebout and Garcia-Pichel, 1995), was apparent (page 390). *The context clues that define the unfamiliar term "greening" are set apart by the appositive, "in which motile cyanobacteria migrate to the surface of the mat." We know that the microorganisms, cyanobacteria, move to the top of the microbial mat causing the mat to become greener since cyanobacteria have a blue-green pigment.*

G 9. Furthermore, many mat microorganisms are motile, utilizing light and /or UV radiation as a cue to **adjust their position in the mats vertically** (Castenholz, 1994; Bebout and Garcia-Pichel, 1995) (page 398). *The context clue, adjust their position in the mats vertically, indicates that motile refers to movement.*

H 10. In this way, **exposure** of the **deeper anaerobic layers of the mats to air and light was minimized** (page 385). *Word parts and context clues reveal the meaning of the word anaerobic. The context clues "exposure" and "deeper anaerobic layers of the mats to air and light was minimized" indicate that the anaerobic layer does not have contact with air and light. No air present, means an environment without oxygen. Also, the absence of light does not allow photosynthesis. A break down of the word parts confirms this guess: a and an are Greek prefixes meaning not, without, or lacking. The Greek prefix aero, aer means air, atmosphere, or gas. The Middle English suffix, ic, is used after nouns to form adjectives meaning of or relating to or it is used after nouns to form adjectives meaning having some characteristics of or in the style of. When you combine the definitions of the word parts, something anaerobic exists without oxygen.*

Prefixes, Suffixes and Roots

Prefix	Suffix	Root
aero, aer- (Greek) air, atmosphere, gas	ic- (Middle English) used after nouns to form adjectives meaning: of or relating to; used after nouns to form adjectives meaning: having some characteristics of; in the style of	astro- (Greek) star, heavenly body, outer space
atmo- steam; vapor	ion- condition or action	bene- (Latin) well
auto- (Greek) self	ine- (Latin) of or relating to	geo- (Greek) the earth, ground
a, an- (Greek) not, without, lacking	logy- (Middle English) study of, field of study, discipline, list of	gen- (Greek) origin or source
bio- (Greek) life		meter- (Greek) measure
chem- chemicals, chemical		troph- (Greek) food, nourishment
di- (Greek) two, double		
eco- home		
electro- (New Latin) electric, electricity		
hyper- (Greek) used before nouns and adjectives excessive, overly, too much, unusual		
hypo- (Greek) under, beneath		
in- (Old English)used before verbs and nouns meaning in, into, on		
in- (Latin) used before adjectives meaning not		
iso- (Greek) equal		
litho- (Greek) stone		
micro- (Latin) 1) small or very small in comparison with others of it's kind 2) restricted in scope milli- (Latin) 1/1000		
meta- (Greek) after, along with, beyond, among, behind		
oxy or ox- oxygen		
photo- (Greek) light		
physio, physi, phys- (Greek) nature		
syn- (Greek) with, together		
terra, terr- (Latin) land, earth		

ad, at (Latin) 1)toward, to 2) near, at

chrono-(Greek) time

flu, fluct, flux-(Latin) to flow

hetero- (Greek) different

logic- (Greek) of reasoning, logic

sal- (Latin) salt

topos-(Greek) place

Words for Prefix, Suffix and Root Dissection

anaerobic

astrobiology

autotroph

biogeochemical

biology

ecology

geology

heterotroph

hypersaline

isotope

isotrophic

microbiology

oxygenic

phototrophic

saline

Prefixes, Suffixes and Roots with Related Science Words

ad, at (Latin) 1)toward, to 2) near, at

aero, aer-prefix(Greek) air, atmosphere, gas

astro- root(Greek) star, heavenly body, outer space astrobiology

atmo-prefix() steam; vapor **atmosphere**

auto- prefix (Greek) self **autotroph**

a, an- prefix (Greek) not, without, lacking **anaerobic**

bene-root(Latin) well **beneficial**

bio-prefix (Greek) life **biosphere, biology, biomarker**

chem-prefix ()chemicals, chemical **chemical, biogeochemical**

chrono-(Greek) time **chronology**

di-prefix(Greek) two, double **dioxide**

eco-prefix home **ecology, ecosystem**

electro-prefix (New Latin) electric, electricity

flu, fluct, flux-(Latin) to flow

geo-root(Greek) the earth, ground **geology, biogeochemical**

gen-root(Greek) origin or source **genetic**

hetero- (Greek) different

hyper- prefix(Greek) used before nouns and adjectives excessive, overly, too much, unusual
hypersaline

hypo-prefix (Greek) under, beneath

ic-suffix(Middle English) used after nouns to form adjectives meaning: of or relating to; used after nouns to form adjectives meaning: having some characteristics of; in the style of
isotrophic

ion-suffix condition or action

in- prefix (Old English)used before verbs and nouns meaning in, into, on

in-prefix (Latin) used before adjectives meaning not

ine-suffix (Latin) of or relating to

iso- prefix(Greek) equal	isotope
litho- prefix(Greek) stone	lithosphere
logic- (Greek) of reasoning, logic	
logy- suffix (Middle English) study of, field of study, discipline, list of biology, geology, microbiology	
micro- prefix (Latin) 1) small or very small in comparison with others of it's kind 2) restricted in scope	microbial
milli- prefix (Latin) 1/1000	
meta- prefix (Greek) after, along with, beyond, among, behind	
meter- root(Greek) measure	
oxy or ox- prefix()oxygen	
photo- prefix (Greek) light	photosynthesis
physio, physi, phys- prefix(Greek) nature	
sal- (Latin) salt	hypersaline, saline
syn- prefix (Greek) with, together	photosynthesis
terra, terr- prefix (Latin) land, earth	
topos- (Greek) place	
troph- root (Greek) food, nourishment	phototrophic, autotrophy, heterotroph, isotrophic

Unmarked Think-Aloud: Syntactic Context Clues using Grammar

(A grammar or punctuation rule helps determine word meaning): Questions 1 and 8 from the pre-test

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 1:

INTRODUCTION

MODERN MICROBIAL MATS are thought to be extant representatives of Earth's most ancient ecosystems (Walter, 1976). Geochemical evidence of the existence of photosynthetic microbial mats, and their mineralized counterparts, stromatolites, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989).

Question 8:

In particular, no evidence of the mat "greening," in which motile cyanobacteria migrate to the surface of the mat (Bebout and Garcia-Pichel, 1995), was apparent (page 390).

Unmarked Think-Aloud: Syntactic Context Clues using Grammar

(A grammar or punctuation rule helps determine word meaning): Questions 1 and 8 from the pre-test

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 1:

INTRODUCTION

MODERN MICROBIAL MATS are thought to be extant representatives of Earth's most ancient ecosystems (Walter, 1976). Geochemical evidence of the existence of **photosynthetic microbial mats, and their mineralized counterparts**, stromatolites, has been identified in rocks as old as **3.0 Ga** (Beukes and Lowe, 1989).

Because the word stromatolite is enclosed in commas it explains what has gone before. Here the appositive, stromatolite, gives the word for the definition (of photosynthetic microbial mats, mineralized counterparts) that preceded it. Therefore, a stromatolite would be the microbes layered in minerals that conduct photosynthesis.

Question 8:

In particular, no evidence of the mat “greening,” **in which motile cyanobacteria migrate to the surface of the mat** (Bebout and Garcia-Pichel, 1995), was apparent (page 390).

The context clues that define the unfamiliar term “greening” are set apart by the appositive, “in which motile cyanobacteria migrate to the surface of the mat.” We know that the microorganisms, cyanobacteria, move to the top of the microbial mat causing the mat to become greener since cyanobacteria have a blue-green pigment.

Unmarked ThinkAloud: Multiple Meanings and Context Clues

(Context clues, the words, phrases or sentences around an unfamiliar word, help to determine the meaning of a word that has multiple meanings.): Question 4 from the pre-test

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 4:

When oxygenic photosynthesis ceases at night, the upper layers of the mat become highly reduced and sulfidic (Jørgensen et al., 1979) (page 384).

Unmarked ThinkAloud: Multiple Meanings and Context Clues

(Context clues, the words, phrases or sentences around an unfamiliar word, help to determine the meaning of a word that has multiple meanings.): Question 4 from the pre-test

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 4:

When **oxygenic photosynthesis ceases** at night, the **upper layers of the mat become highly reduced and sulfidic** (Jørgensen et al., 1979) (page 384).

This is an example of a word, reduced, that has multiple meanings and may be used in an unfamiliar way. The context clues in the sentence show that the common definition, to make smaller, is not the best one, because reduced is linked with the word sulfidic through the use of the word "and". Earlier in the sentence, the statement is made, "When oxygenic photosynthesis ceases..." providing the clue that removing oxygen from a substance would be the correct definition.

Another approach would be to look up the unfamiliar word, reduced, in the dictionary and substitute the meanings until one makes sense in the context of the passage.

Unmarked Think-Aloud: Prefixes, Suffixes, and Roots

(Use knowledge of Greek or Latin prefixes, suffixes, and roots to help break down the word into parts to determine meaning.): Questions: 2 and 5

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 2:

Because these microbial mats are considered to be useful analogs of ancient marine communities, they offer insights about evolutionary events during the >3 billion year time interval wherein mats co-evolved with Earth's lithosphere and atmosphere (page 383).

Question 5:

Photosynthetic microbial mat communities were obtained from marine hypersaline saltern ponds, maintained in a greenhouse facility, and examined for the effects of salinity variations (page 383).

Unmarked Think-Aloud: Prefixes, Suffixes, and Roots

(Use knowledge of Greek or Latin prefixes, suffixes, and roots to help break down the word into parts to determine meaning.): Questions: 2 and 5

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 2:

Because these microbial mats are considered to be useful analogs of ancient marine communities, they offer insights about evolutionary events during the >3 billion year time interval wherein mats co-evolved with Earth's lithosphere and atmosphere (page 383).

Breaking the word, lithosphere, into parts helps determine its meaning. Litho is a Greek prefix meaning stone, sphere means round. Literally, the lithosphere is the stone sphere around the earth or the earth's crust and mantle.

Question 5:

Photosynthetic microbial mat communities were obtained from marine hypersaline saltern ponds, maintained in a greenhouse facility, and examined for the effects of salinity variations (page 383).

Break down each of the word parts to find the meaning of this word: hyper is a Greek prefix used before nouns and adjectives meaning excessive, overly, too much, or unusual. The word part, sal is Latin for salt and ine is a Latin suffix meaning of or relating to. Hypersaline would be mean excessively salty.

Unmarked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

(A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 3:

To understand the overall structure and function of mat communities, it is thus critical to determine the nature and extent of the interactions between phototrophic and non-photosynthetic microorganisms, including anaerobic microorganisms (page 384).

Unmarked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

(A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10 continued

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 6:

As dominant components of our biosphere for at least 2 billion years of its >3.5 billion year history, microbial mats played a pivotal role in shaping the composition of Earth's early atmosphere, including its eventual oxygenation (page 385).

Unmarked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10 continued

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 10:

In this way, exposure of the deeper anaerobic layers of the mats to air and light was minimized (page 385).

Unmarked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

(A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 3:

To understand the overall structure and function of mat communities, it is thus critical to determine the nature and extent of the interactions between phototrophic and non-photosynthetic microorganisms, including anaerobic microorganisms (page 384).

). The meaning of the word phototrophic can be determined through a combination of grammatical context clues and a study of prefixes, suffixes and roots. The grammatical structure, interactions between phototrophic and non-photosynthetic microorganisms, implies a contrast between microorganisms that are phototrophic and those that are non-photosynthetic. It can be inferred that phototrophic organisms are photosynthetic, since there is an interaction between those organisms that are phototrophic and those that are non-photosynthetic. A study of the word parts confirms this guess from context clues. **Photo** is a Greek prefix that means light. **Troph** is a Greek root means nourishment. The affix, **ic**, is Middle English suffix which means relating to. If a phototroph is a microorganism that relates to getting nourishment from light, then a phototrophic organism is photosynthetic and able to obtain energy through light.

Unmarked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

(A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10 continued

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 6:

As dominant components of our biosphere for at least 2 billion years of its >3.5 billion year history, microbial mats played a pivotal role in shaping the composition of Earth's early atmosphere, including its eventual oxygenation (page 385).

Context clues and word part analysis help one to determine the meaning of this word. If one knows that the atmosphere is composed of oxygen and other gasses, then one can guess that oxygenation has something to do with oxygen. When one looks at the word parts, one finds that the oxy or ox-prefix means oxygen, gen is a Greek root which means origin or source, and ion is a suffix which means condition or action. Put it together and one has the condition or action of the origination of oxygen.

Unmarked Think-Aloud: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10 continued

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 10:

In this way, exposure of the deeper anaerobic layers of the mats to air and light was minimized (page 385).

Word parts and context clues reveal the meaning of the word anaerobic. The context clues "exposure" and "deeper anaerobic layers of the mats to air and light was minimized" indicate that the anaerobic layer does not have contact with air and light. No air present means an environment without oxygen. Also, the absence of light does not allow photosynthesis. A break down of the word parts confirms this guess: a and an are Greek prefixes meaning not, without, or lacking. The Greek prefix aero or aer means air, atmosphere, or gas. The Middle English suffix, ic, is used after nouns to form adjectives meaning of or relating to or it is used after nouns to form adjectives meaning having some characteristics of or in the style of. When you combine the definitions of the word parts, something anaerobic exists without oxygen.

Unmarked Think-Aloud: Semantic Context Clues

(The words, phrases or sentences around an unfamiliar word that help determine its meaning.): Question 7 and 9

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 7:

Normal *in situ* daily water column temperature variations were simulated in the greenhouse by (1) controlling the temperature increase (attributable to solar heating) during the daytime to stay below the maximum temperature observed *in situ* and (2) turning off temperature control at night to allow the water temperature in the flow boxes to decrease slowly with the decrease in greenhouse air temperature (page 387).

Question 9:

Furthermore, many mat microorganisms are **motile**, utilizing light and /or UV radiation as a cue to adjust their position in the mats vertically (Castenholz, 1994; Bebout and Garcia-Pichel, 1995) (page 398).

Unmarked Think Aloud: Semantic Context Clues

(The words, phrases or sentences around an unfamiliar word that help determine its meaning.): Question 7 and 9

Selections from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Question 7:

Normal *in situ* **daily** water column temperature variations **were simulated in the greenhouse** by
(1) controlling the temperature increase (attributable to solar heating) during the daytime **to stay**
below the maximum temperature observed *in situ* and
(2) turning off temperature control at night to allow the water temperature in the flow boxes to decrease slowly with the decrease in greenhouse air temperature
(page 387).

The context clues, normal, daily, were simulated in the greenhouse, as well as, to stay below the maximum temperature observed in situ indicate that in situ would be the opposite of conditions in the greenhouse, or the conditions in the natural environment. Also the italics indicate that it is another language, Latin in this case, from the web "Latin for 'in original place.' Refers to measurements made at the actual location of the object or material measured."

Question 9:

Furthermore, many mat microorganisms are **motile**, utilizing light and /or UV radiation as a cue to **adjust their position in the mats vertically** (Castenholz, 1994; Bebout and Garcia-Pichel, 1995) (page 398).

The context clue, adjust their position in the mats vertically, indicates that motile refers to movement.

Latin Phrase information about **in situ**

© 1999-2005 by [GuruNet](http://www.answers.com/topic/in-situ?method=5&linktext=In%20Situ). All rights reserved. <http://www.answers.com/topic/in-situ?method=5&linktext=In%20Situ>

Unmarked Paragraph from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

INTRODUCTION

MODERN MICROBIAL MATS are thought to be extant representatives of Earth's most ancient ecosystems (Walter, 1976). Geochemical evidence of the existence of photosynthetic microbial mats, and their mineralized counterparts, stromatolites, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989). As a living repository of genetic, physiological, isotopic, and biogeochemical information on the co-evolution of a planet and the only known biosphere, modern microbial mats are invaluable objects of study. Modern microbial mat studies have provided important insights on rates of biological activity (Revsbech et al., 1983; Canfield and Des Marais, 1993; Des Marais, 1995), genetic diversity (Ward et al., 1990; Garcia-Pichel et al., 1998; Nübel et al., 2001), stable isotopic fractionation (Schidlowski, 1988; Des Marais and Canfield, 1994), and organic (Boon, 1984; Ward et al., 1985) and atmospheric (Visscher and Van Gernerden, 1991; Visscher and Kiene, 1994; Hoehler et al., 2001) biomarkers, as well as minerals (Reid et al., 2000), that have been used to interpret the fossil record of these communities over geologic time.

Marked Paragraph: Prefixes, Suffixes, and Roots

(Use knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions: 2 and 5

Paragraph from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

INTRODUCTION

MODERN MICROBIAL MATS are thought to be extant representatives of Earth's most ancient ecosystems (Walter, 1976). Geochemical evidence of the existence of photosynthetic microbial mats, and their mineralized counterparts, stromatolites, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989). As a living repository of genetic, physiological, isotopic, and biogeochemical information on the co-evolution of a planet and the only known biosphere, modern microbial mats are invaluable objects of study. Modern microbial mat studies have provided important insights on rates of biological activity (Revsbech et al., 1983; Canfield and Des Marais, 1993; Des Marais, 1995), genetic diversity (Ward et al., 1990; Garcia-Pichel et al., 1998; Nübel et al., 2001), stable isotopic fractionation (Schidlowski, 1988; Des Marais and Canfield, 1994), and organic (Boon, 1984; Ward et al., 1985) and atmospheric (Visscher and Van Gernerden, 1991; Visscher and Kiene, 1994; Hoehler et al., 2001) biomarkers, as well as minerals (Reid et al., 2000), that have been used to interpret the fossil record of these communities over geologic time.

Marked Paragraph: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

(A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Questions 3, 6 and 10

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

INTRODUCTION

MODERN MICROBIAL MATS are thought to be extant representatives of Earth's most ancient ecosystems (Walter, 1976). Geochemical evidence of the existence of photosynthetic microbial mats, and their mineralized counterparts, stromatolites, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989). As a living repository of genetic, physiological, isotopic, and biogeochemical information on the co-evolution of a planet and the only known biosphere, modern microbial mats are invaluable objects of study. Modern microbial mat studies have provided important insights on rates of biological activity (Revsbech et al., 1983; Canfield and Des Marais, 1993; Des Marais, 1995), genetic diversity (Ward et al., 1990; Garcia-Pichel et al., 1998; Nübel et al., 2001), stable isotopic fractionation (Schidlowski, 1988; Des Marais and Canfield, 1994), and organic (Boon, 1984; Ward et al., 1985) and atmospheric (Visscher and Van Gernerden, 1991; Visscher and Kiene, 1994; Hoehler et al., 2001) biomarkers, as well as minerals (Reid et al., 2000), that have been used to interpret the fossil record of these communities over geologic time.

Marked Paragraph: Semantic Context Clues

(The words, phrases or sentences around an unfamiliar word that help determine its meaning.): Question 7 and 9

Paragraph from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

INTRODUCTION

MODERN MICROBIAL MATS are thought to be extant representatives of Earth's most ancient ecosystems (Walter, 1976). Geochemical evidence of the existence of photosynthetic microbial mats, and their mineralized counterparts, **stromatolites**, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989). As a living repository of genetic, physiological, isotopic, and biogeochemical information on the co-evolution of a planet and the only known biosphere, modern microbial mats are invaluable objects of study. Modern microbial mat studies have provided important insights on rates of biological activity (Revsbech et al., 1983; Canfield and Des Marais, 1993; Des Marais, 1995), genetic diversity (Ward et al., 1990; Garcia-Pichel et al., 1998; Nübel et al., 2001), stable isotopic fractionation (Schidlowski, 1988; Des Marais and Canfield, 1994), and organic (Boon, 1984; Ward et al., 1985) and atmospheric (Visscher and Van Gernerden, 1991; Visscher and Kiene, 1994; Hoehler et al., 2001) biomarkers, as well as minerals (Reid et al., 2000), that have been used to interpret the fossil record of these communities over geologic time.

Unmarked Think-Pair-Share: Syntactic Context Clues Using Grammar

(A grammar or punctuation rule helps determine word meaning): Pretest Reference: Questions 1 and 8

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 388.

What clues help determine the meaning of the highlighted word?

Oxygen microelectrode signal output was calibrated to oxygen concentrations using a two-point calibration.

Because the water circulating through the flow boxes was constantly **aerated** through the action of the pumps and through contact with the atmosphere across a large surface area of water, the electrode current at any point in the water overlying the mats was taken to be equal to the current produced in air-saturated water at that particular temperature and salinity. The exact value of this oxygen concentration can then be identified using published values (Sherwood et al., 1991).

Marked Think-Pair-Share: Syntactic Context Clues Using Grammar

(A grammar or punctuation rule helps determine word meaning): Pretest Reference: Questions 1 and 8

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 388.

What clues help determine the meaning of the highlighted word?

Oxygen microelectrode signal output was calibrated to oxygen concentrations using a two-point calibration. Because the water circulating through the flow boxes was constantly **aerated** through the action of the pumps and through contact with the atmosphere across a large surface area of water, the electrode current at any point in the water overlying the mats was taken to be equal to the current produced in air-saturated water at that particular temperature and salinity. The exact value of this oxygen concentration can then be identified using published values (Sherwood et al., 1991).

Explanation:

Several clues help determine the meaning of the word aerated. First, the sentence indicates that the water is circulating. Second, the sentence explains how the water was aerated, “through the action of the pumps and through contact with the atmosphere across a large surface area of water.” The word **through** indicates grammatically how the aeration happens for it signals an explanation. The words in the sentence that follow **through** explain that the water is being circulated with air. This meaning is confirmed by comparing the “current produced in air-saturated water,” indicating that aeration involves adding air to something.

Marked Think-Pair-Share: Multiple Meanings and Context Clues

(Context clues, the words, phrases or sentences around an unfamiliar word, help to determine the meaning of a word that has multiple meanings): Pretest Reference: Questions 4

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 398.

What words, phrases or sentences help you determine the meaning of the highlighted word below?

When compared with previous efforts to maintain microbial mats, our results indicate that two factors—water flow and the light **regime**—are likely to be more important than others in simulating the field environment.

Marked Think-Pair-Share: Multiple Meanings and Context Clues

(Context clues, the words, phrases or sentences around an unfamiliar word, help to determine the meaning of a word that has multiple meanings): Pretest Reference: Questions 4

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 398.

What words, phrases or sentences help you determine the meaning of the highlighted word below?

When compared with previous efforts to maintain microbial mats, our results indicate that two factors—water flow and the light **regime**—are likely to be more important than others in simulating the field environment.

Explanation:

The common meaning for regime is a type of government. However, when one reads the sentence, this does not work. If one turns to the sentence, one finds some clues that hint at the meaning of regime. The sentence has several words that help one put together a meaning for regime. The sentence starts out “When compared with previous efforts to maintain microbial mats, our results indicate that two factors...” and then goes on to state that light regime is one of the factors. We can conclude that light regime is an effort to maintain a mat. Next, the sentence states that these factors “are likely to be more important than others in simulating the field environment.” The field environment is where the mats live in nature. Light is a requirement for the life of the mat. The light regime must be a regular cycle of light like in the field. When one compares this idea with the dictionary, one finds this is true. One of the definitions that Merriam Webster’s Collegiate Dictionary, Eleventh Edition has for regime is, “A regular pattern of occurrence or action.” Thus, the light regime is a regular pattern of light given to the mats in the green house community.

Unmarked Think-Pair-Share: Prefixes, Suffixes, and Roots

(Use knowledge of Greek or Latin prefixes, suffixes, and roots to help break down the word into parts to determine meaning): Pretest Reference: Questions 2 and 5

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 390.

How can your knowledge of Greek or Latin prefixes, suffixes and roots help you determine the meaning of the highlighted word below?

More specifically, the major populations of cyanobacteria did not seem to change, and *M. chthonoplastes* remained the dominant **phototroph** in all of the sections of mat characterized microscopically.

Explanation:

Marked Think-Pair-Share: Prefixes, Suffixes, and Roots

Use knowledge of Greek or Latin prefixes, suffixes, and roots to help break down the word into parts to determine meaning): Pretest Reference: Questions 2 and 5

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 390.

How can your knowledge of Greek or Latin prefixes, suffixes and roots help you determine the meaning of the highlighted word below?

More specifically, the major populations of cyanobacteria did not seem to change, and *M. chthonoplastes* remained the dominant **phototroph** in all of the sections of mat characterized microscopically.

Explanation:

Photo is the Greek prefix meaning light and troph is a Greek root meaning food. Combine the two word part definitions to mean light food or an organism that produces food using light.

Unmarked Think-Pair-Share: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

(A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Pretest Reference: Questions 3, 6 and 10

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 397.

Oxygen **microprofiles**, measured using microelectrodes, and oxygen and carbon fluxes, measured using flux chambers, were found to be comparable in greenhouse and freshly collected natural mats.

Unmarked Think-Pair-Share: Syntactic Context Clues using Grammar and Prefixes, Suffixes, and Roots

(A grammar or punctuation rule helps determine word meaning when combined with a knowledge of Greek or Latin prefixes, suffixes, and roots helps to break down the word into parts to determine meaning.): Pretest Reference: Questions 3, 6 and 10

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 397.

Oxygen **microprofiles**, measured using microelectrodes, and oxygen and carbon fluxes, measured using flux chambers, were found to be comparable in greenhouse and freshly collected natural mats.

Explanation:

The meaning of the word microprofile can be determined from the Latin prefix micro, which means small and the word profile means the graphical presentation of measurements. If one looks at the words in the sentence around microprofile, one finds that oxygen is measured. One can draw the conclusion that the microprofiles portray the oxygen measured.

Unmarked Think-Pair-Share: Semantic Context Clues

(The words, phrases or sentences round an unfamiliar word that help determine its meaning.): Pretest Reference: Questions 7 and 9

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 398.

Therefore, flow variations around the 5 cm s⁻¹ value will minimally affect the **fluxes** in and out of the mat.

Unmarked Think-Pair-Share: Semantic Context Clues

(The words, phrases or sentences round an unfamiliar word that help determine its meaning.): Pretest Reference: Questions 7 and 9

Selection from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 398.

Therefore, flow variations around the 5 cm s⁻¹ value will minimally affect the **fluxes** in and out of the mat.

Explanation:

Around the word **fluxes** are the words “in and out of the mat” indicating a rate of change in flow variations and giving the meaning of the word, **flux**.

Posttest

Posttest of words used in Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

- A. one who is authorized to act for another
- B. the process of using light as an energy source to make food
- C. organisms that have more than one cell
- D. the cycling of chemicals into the living and nonliving parts of an ecosystem
- E. organisms that have one cell
- F. a taste in fine arts
- G. a layered community of microorganisms
- H. loose fluffy material
- I. a program designed to gather information
- J. to grow in a prepared mixture

Match the highlighted words in each passage on the left, with the letter of the correct definition located at the top of the page. Underline the words or parts that give a clue to the meaning of the bold word in the sentence.

_____1. Within the collaboratory, intelligent software **agents** will assist in the experimentation process controlling the hardware, troubleshooting, re-cording results, and reporting back to collaborating experimenters.

_____2. A **microbial mat** is a highly complex assemblage of organisms possessing many different modes of metabolism, all of which are interacting with each other at some level in beneficial and/or competitive ways.

_____3. Measurements of rates of biogeochemical cycling in greenhouse mats were similar to rates measured on freshly collected mats (Table 2).

_____4. In **photosynthetic** microbial mats, all of the energy necessary for growth and maintenance of the community is ultimately derived from the sun.

_____5. During the first few weeks of greenhouse incubation, there was a notable increase in the abundance of loosely attached microbial **"floc"** at the surface of the mats, as well the development of small dark green spots containing large numbers of cyanobacterial filaments in some mats. However, after the first 2 months, the loose floc disappeared, and the mat surface was smooth and homogeneous in appearance once again.

_____6. Nonquantitative microscopic observations revealed an increase in the abundance of **unicellular** cyanobacteria that resembled the *Halothece* type at the surface of the HIGH salinity mats relative to those maintained at NORMAL salinity.

_____7. Either some microbial processes do not occur in **culture** [eg., anaerobic methane oxidation (Reeburgh, 1980) and sulfate reduction under aerobic conditions (Canfield and Des Marais, 1991)], or they occur at rates vastly different than rates observed in nature. In addition, relatively few (<1%) of the total number of microbes present in nature are available in **culture** (Ward et al., 1990; Amann *et al.*, 1995).

Posttest

Posttest of words used in Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

- A. one who is authorized to act for another
- B. the process of using light as an energy source to make food
- C. organisms that have more than one cell
- D. the cycling of chemicals into the living and nonliving parts of an ecosystem
- E. organisms that have one cell
- F. a taste in fine arts
- G. a layered community of microorganisms
- H. loose fluffy material
- I. a program designed to gather information
- J. to grow in a prepared mixture

Match the highlighted words in each passage on the left, with the letter of the correct definition located at the top of the page. Underline the words or parts that give a clue to the meaning of the bold word in the sentence.

I 1. Within the collaboratory, intelligent software **agents** will assist in the experimentation process controlling the hardware, troubleshooting, re-cording results, and reporting back to collaborating experimenters. *at the common definition, to make smaller, is not the best one, because reduced is linked with the word sulfidic through the use of the word "and". Earlier in the sentence, the statement is made, "When oxygenic photosynthesis ceases..." providing the clue that removing oxygen from a su*

G 2. A **microbial mat** is a highly complex assemblage of organisms possessing many different modes of metabolism, all of which are interacting with each other at some level in beneficial and/or competitive ways. *Syntactic Context Clues using Grammar: The linking word is tells what a microbial mat. A microbial mat is an assemblage of organisms or a layered community of microorganisms.*

D 3. Measurements of rates of **biogeochemical** cycling in greenhouse mats were similar to rates measured on freshly collected mats (Table 2). *Prefixes, Suffixes and Roots: bio is a Greek prefix meaning life, geo is a Greek root meaning the earth or ground and chemical means the composition, structure and properties of a substance and the changes it makes. A combination of these affix and word meanings indicates living and nonliving changes.*

B 4. In **photosynthetic** microbial mats, all of the energy necessary for growth and maintenance of the community is ultimately derived from the sun. *Syntactic Context Clues using Grammar: photo is Greek prefix meaning light, sny is a Greek prefix meaning together or with. This yields a meaning of something occurring with light. If you use the grammar clues in the sentence it says that all of the energy necessary for growth and maintenance of the community is joined by the linking verb is showing that the energy comes from the sun. Indicating that photosynthesis is a process that uses light as energy for growth.*

H 5. During the first few weeks of greenhouse incubation, there was a notable increase in the abundance of loosely attached microbial **"floc"** at the surface of the mats, as well the development of small dark green spots containing large numbers of cyanobacterial filaments in some mats. However, after the first 2 months, the loose floc disappeared, and the mat surface was smooth and homogeneous in appearance once again. *Semantic context clues: The words loosely attached and loose around the word floc indicate a loose substance on the mat. The word floc is also contrasted with floc disappearing and then the mat surface is smooth and homogeneous in appearance once again. This provides further clues that floc is loose materials.*

E 6. Nonquantitative microscopic observations revealed an increase in the abundance of **unicellular** cyanobacteria that resembled the Halothece type at the surface of the HIGH salinity mats relative to those maintained at NORMAL salinity. *Suffixes and Roots: uni is prefix meaning one. When you combine this with the word, then the word means one celled.*

J 7. Either some microbial processes do not occur in **culture** [eg., anaerobic methane oxidation (Reeburgh, 1980) and sulfate reduction under aerobic conditions (Canfield and Des Marais, 1991)], or they occur at rates vastly different than rates observed in nature. In addition, relatively few (<1%) of the total number of microbes present in nature are available in **culture** (Ward et al., 1990; Amann et al., 1995). *Multiple Meanings and Context Clues: If culture is something associated with the arts, then one will soon learn that culture as used in this sentence does not fix this meaning. However, the context clues contrast what is happening in culture with "or they occur at rates vastly different than rates observed in nature" this contrast provides the hint that culture is not nature and culture is growing something by artificial means.*

Narrative Retelling Model from:

Bucaria, R. and Bebout B., *A Teacher's Guide to Stromatolite Explorer*. Microbes @ NASA. <http://microbes.arc.nasa.gov> p.9.

Question: What is a microbial mat?

Answer:

A microbial mat is a community of microorganisms that is only a few millimeters thick. Within the community, each organism produces chemical compounds, (gases, sugars or other organic substances) used by other members of the community to gain energy. Different types of microbes are located at different depths within the mat, based on their own chemical and light requirements. This creates the distinctive layered appearance of mats. If one slices a mat and looks at it from the side, it can be seen that the upper brown layer contains diatoms, cyanobacteria conducting photosynthesis compose the green layer, and the pink layer, contains purple sulfur bacteria. The dark areas, where oxygen is not present, is inhabited by fermenters, and sulfate reducing bacteria. Colorless sulfur bacteria are always at the interface of the oxygen containing, and anoxic layers. When light and chemical conditions change, at night for example, colorless sulfur bacteria move to the top of the mat, since oxygen is not present in the lower layers.

Narrative Retelling Model from:

Bucaria, R. and Bebout B., *A Teacher's Guide to Stromatolite Explorer*. Microbes @ NASA. <http://microbes.arc.nasa.gov> p.9.

Question: What is a microbial mat?

Answer:

A¹ microbial mat is a community of microorganisms that is² only a few millimeters thick. Within the community,³ each organism produces chemical compounds, (gases, sugars or other organic substances) used by other members of the community to gain energy.⁴ Different types of microbes are located at different depths within the mat, based on their own chemical and light requirements. This creates the distinctive⁵ layered appearance of mats. If one slices a mat and looks at it from the side, it can be seen that the upper⁶ brown layer contains diatoms,⁷ cyanobacteria conducting photosynthesis compose the green layer, and the⁸ pink layer, contains purple sulfur bacteria. The⁹ dark areas, where oxygen is not present, is¹⁰ inhabited by fermenters, and sulfate reducing bacteria.¹¹ Colorless sulfur bacteria are always at the interface of the oxygen containing, and¹² anoxic layers. When¹³ light and chemical conditions change, at night for example, colorless sulfur bacteria move to the top of the mat, since oxygen is not present in the lower layers.

Rephrasing Activity for Narrative Retelling

NAME _____

- 1) Rephrase main ideas in your own words.
- 2) Number the ideas in the order you want to write about them.
- 3) Write your narrative.

Words from the Article	Rephrasing
only a few millimeters thick.	
microbial mat is a community of microorganisms	
each organism produces chemical compounds, (gases, sugars or other organic substances) used by other members of the community to gain energy.	
Different types are located at different depths within the mat, based on their own chemical and light requirements.	
layered appearance of mats.	
brown layer contains diatoms	
cyanobacteria conducting photosynthesis compose the green layer	
pink layer, contains purple sulfur bacteria.	
dark areas, where oxygen is not present, are	
inhabited by fermenters, sulfate reducing bacteria.	
Colorless sulfur bacteria are always at the interface of the oxygen containing, and anoxic layers.	
interface of the oxygen containing, and anoxic layers.	
light and chemical conditions change, at night for example, colorless sulfur bacteria move to the top of the mat, since oxygen is not present in the lower layers.	

Rephrasing Activity for Narrative Retelling

NAME _____

- 1) Rephrase main ideas in your own words.
- 2) Number the ideas in the order you want to write about them.
- 3) Write your narrative.

Words from the Article	Rephrasing
only a few millimeters thick.	lots of microorganisms live in a mat that work together
microbial mat is a community of microorganisms	mats are small –millimeters deep
each organism produces chemical compounds, (gases, sugars or other organic substances) used by other members of the community to gain energy.	Microorganism gain energy by materials produced by organisms living in the mat. Mat organisms produce organic substances, sugars, and gases.
Different types are located at different depths within the mat, based on their own chemical and light requirements.	Mat organisms live where they have the light and chemicals they need. Different organisms need different things,
layered appearance of mats.	Mats are layered like lasagna.
brown layer contains diatoms	Diatoms live in brown layer.
cyanobacteria conducting photosynthesis compose the green layer	Cyanobacteria the green layer—they take light and water and produce oxygen through photosynthesis
pink layer, contains purple sulfur bacteria.	Purple sulfur bacteria live in the pink part of the mat.
dark areas, where oxygen is not present, are	Oxygen is not produced in the dark areas of the mat.
inhabited by fermenters, sulfate reducing bacteria.	dark layers without oxygen contain sulfate reducing bacteria and fermenters(What is this? Look it up.)
Colorless sulfur bacteria are always at the interface of the oxygen containing, and anoxic layers.	Living at areas where there is oxygen and no oxygen are colorless sulfur bacteria.
interface of the oxygen containing, and anoxic layers.	Anoxic doesn't contain oxygen
light and chemical conditions change, at night for example, colorless sulfur bacteria move to the top of the mat, since oxygen is not present in the lower layers.	Colorless sulfur bacteria need oxygen since they move to the top of the mat at night when oxygen is not lower in the mat. CSB are microbes that move to find what they need in the mat.

Introductory Paragraph to use with Narrative Retelling from:

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

INTRODUCTION

MODERN MICROBIAL MATS are thought to be extant representatives of Earth's most ancient ecosystems (Walter, 1976).

Geochemical evidence of the existence of photosynthetic microbial mats, and their mineralized counterparts, stromatolites, has been identified in rocks as old as 3.0 Ga (Beukes and Lowe, 1989). As a living repository of genetic, physiological, isotopic, and biogeochemical information on the co-evolution of a planet and the only known biosphere, modern microbial mats are invaluable objects of study. Modern microbial mat studies have provided important insights on rates of biological activity (Revsbech et al., 1983; Canfield and Des Marais, 1993; Des Marais, 1995), genetic diversity (Ward et al., 1990; Garcia-Pichel et al., 1998; Nübel et al., 2001), stable isotopic fractionation (Schidlowski, 1988; Des Marais and Canfield, 1994), and organic (Boon, 1984; Ward et al., 1985) and atmospheric (Visscher and Van Gernerden, 1991; Visscher and Kiene, 1994; Hoehler et al., 2001) biomarkers, as well as minerals (Reid et al., 2000), that have been used to interpret the fossil record of these communities over geologic time.

Rephrasing Activity for Narrative Retelling

NAME _____

- 1) Rephrase main ideas in your own words.
- 2) Number the ideas in the order you want to write about them.
- 3) Write your narrative.

Words from the Article	Rephrasing

Narrative Retelling Rubric	4 Exemplary	3 Accomplished	2 Developing	1 Below Standard
<p><i>Content from Article</i></p> <p>Microbial mats represent early earth ecosystems, are found in fossils 3.0 Ga old, exist today, are photosynthetic, and help scientists understand evolution of planet and biosphere through biological activity, isotopic information diversity of organisms (genetics), organic and atmospheric biomarkers, minerals and physiological information.</p>	<p>Content is clearly defined and contains complete information on microbial mats. Writing demonstrates comprehensive understanding of article. Additional research enlightens understanding of information in the article.</p>	<p>Content is defined and contains complete information on microbial mats. Writing demonstrates understanding of article. The author uses research to clarify information in the article.</p>	<p>Content is not clearly defined and some information on microbial mats is missing. Writing demonstrates partial understanding of article. The author may have used research to clarify information in the article.</p>	<p>Content is not present, information on microbial mats is missing. Writing does not demonstrate understanding of the article. No attempt is made to use additional research to clarify information found in the article.</p>
<p><i>Organization</i></p>	<p>Organization is clearly defined with a beginning, middle and end. Structure helps to present relevant facts, details and explanations about microbial mats in a clear and interesting manner.</p>	<p>Organization is defined with a beginning, middle and end. Structure helps to present relevant facts, details and explanations about microbial mats in a coherent manner.</p>	<p>Organization is unclear. The beginning, middle or end of the writing may not be defined clearly. Structure is confusing and relevant facts, details and explanations about microbial mats are not presented in a coherent manner.</p>	<p>Organization is lacking. The beginning, middle or end of the writing is not present. Structure is not present and if facts, details and explanations about microbial mats are included, they are not organized or missing.</p>

Narrative Retelling Rubric	4 Exemplary	3 Accomplished	2 Developing	1 Below Standard
<i>Conventions</i>	Contains few errors in spelling, punctuation and grammar. Errors do not interfere with the reader's understanding of the writing.	Contains some errors in spelling, punctuation and grammar. Errors do not interfere with the reader's understanding of the writing.	Contains several errors in spelling, punctuation and grammar. Errors may interfere with the reader's understanding of the writing.	Contains serious errors in spelling, punctuation and grammar. Errors interfere with the reader's understanding of the writing.
<i>Genre Select the appropriate genre for scoring.</i> • Narration	Story has clearly defined plot and character development. Writing masterfully captures attention and sustains interest. Word choice vividly conveys details of character development, setting and plot.	Story plot and character development is defined. Writing gains attention and keeps interest. Word choice conveys details of character development, setting and plot.	Story plot and character development is unclear. Writing wavers in its ability to grab attention and keep interest. Word choice is unclear and does not fully convey details of character development, setting and plot.	Story plot and character development is not present. Writing fails to grab attention and keep interest. Word choice is lacking and does not convey details of character development, setting and plot.
• Picture Book	Story clearly utilizes the same structure as the original text. Writing masterfully captures attention and sustains interest. Word choice vividly conveys details and effectively contributes to the fluency of the text.	Story utilizes the same structure as the original text. Writing gains attention and keeps interest. Word choice conveys details and contributes to the fluency of the text.	It is unclear whether the story utilizes the structure of the original text. Writing wavers in its ability to grab attention and keep interest. Word choice is unclear and does not fully contribute to the fluency of the text.	Original text structure is not present. Writing fails to grab attention and keep interest. Word choice is lacking and does not contribute to the fluency of the text.
• Poem	Poem clearly portrays images that are vivid and detailed. Line breaks and rich creative word choice emphasize meaning. Clearly defined flow or rhythm draws readers into the content of the poem.	Poem portrays images. Line breaks and word choice define meaning. Flow or rhythm conveys the content of the poem.	Poem portrays unclear images. Line breaks and word choice may confuse meaning. Flow or rhythm may not consistently convey the content of the poem.	Poem images are not present. Line breaks and word choice confuse meaning. Flow or rhythm distracts from the content of the poem.

Narrative Retelling Rubric	4 Exemplary	3 Accomplished	2 Developing	1 Below Standard
<i>Content from Article</i>	Content is clearly defined and contains complete information on microbial mats. Writing demonstrates comprehensive understanding of article. Additional research enlightens understanding of information in the article.	Content is defined and contains complete information on microbial mats. Writing demonstrates understanding of article. The author uses research to clarify information in the article.	Content is not clearly defined and some information on microbial mats is missing. Writing demonstrates partial understanding of article. The author may have used research to clarify information in the article.	Content is not present, information on microbial mats is missing. Writing does not demonstrate understanding of the article. No attempt is made to use additional research to clarify information found in the article.
<i>Organization</i>	Organization is clearly defined with a beginning, middle and end. Structure helps to present relevant facts, details and explanations about microbial mats in a clear and interesting manner.	Organization is defined with a beginning, middle and end. Structure helps to present relevant facts, details and explanations about microbial mats in a coherent manner.	Organization is unclear. The beginning, middle or end of the writing may not be defined clearly. Structure is confusing and relevant facts, details and explanations about microbial mats are not presented in a coherent manner.	Organization is lacking. The beginning, middle or end of the writing is not present. Structure is not present and if facts, details and explanations about microbial mats are included, they are not organized or missing.

Narrative Retelling Rubric	4 Exemplary	3 Accomplished	2 Developing	1 Below Standard
<i>Conventions</i>	Contains few errors in spelling, punctuation and grammar. Errors do not interfere with the reader's understanding of the writing.	Contains some errors in spelling, punctuation and grammar. Errors do not interfere with the reader's understanding of the writing.	Contains several errors in spelling, punctuation and grammar. Errors may interfere with the reader's understanding of the writing.	Contains serious errors in spelling, punctuation and grammar. Errors interfere with the reader's understanding of the writing.
<i>Genre Select the appropriate genre for scoring.</i> • Narration	Story has clearly defined plot and character development. Writing masterfully captures attention and sustains interest. Word choice vividly conveys details of character development, setting and plot.	Story plot and character development is defined. Writing gains attention and keeps interest. Word choice conveys details of character development, setting and plot.	Story plot and character development is unclear. Writing wavers in its ability to grab attention and keep interest. Word choice is unclear and does not fully convey details of character development, setting and plot.	Story plot and character development is not present. Writing fails to grab attention and keep interest. Word choice is lacking and does not convey details of character development, setting and plot.
• Picture Book	Story clearly utilizes the same structure as the original text. Writing masterfully captures attention and sustains interest. Word choice vividly conveys details and effectively contributes to the fluency of the text.	Story utilizes the same structure as the original text. Writing gains attention and keeps interest. Word choice conveys details and contributes to the fluency of the text.	It is unclear whether the story utilizes the structure of the original text. Writing wavers in its ability to grab attention and keep interest. Word choice is unclear and does not fully contribute to the fluency of the text.	Original text structure is not present. Writing fails to grab attention and keep interest. Word choice is lacking and does not contribute to the fluency of the text.
• Poem	Poem clearly portrays images that are vivid and detailed. Line breaks and rich creative word choice emphasize meaning. Clearly defined flow or rhythm draws readers into the content of the poem.	Poem portrays images. Line breaks and word choice define meaning. Flow or rhythm conveys the content of the poem.	Poem portrays unclear images. Line breaks and word choice may confuse meaning. Flow or rhythm may not consistently convey the content of the poem.	Poem images are not present. Line breaks and word choice confuse meaning. Flow or rhythm distracts from the content of the poem.

References

All America Reads. *Lesson Plan*.

<http://www.allamericareads.org/lessonplan/strategies/vocab>

Bebout, Brad M. et al. (2002), *Long-Term Manipulations of Intact Microbial Mat Communities in a Greenhouse Collaboratory: Simulating Earth's Present and Past Field Environments*, *Astrobiology* 2, 383-402.

Bebout, Brad M. (2005) *Microbes @ NASA*. <http://microbes.arc.nasa.gov>

Beers, Kylene. *When Kids Can't Read What Teachers Can Do*. Portsmouth, NH: Heinemann, 2003.

Bucaria, R. and Bebout B., *A Teacher's Guide to Stromatolite Explorer*. *Microbes @ NASA*. <http://microbes.arc.nasa.gov> p.9.

Buchanan. *How to teach students to read for themselves, actively, and analytically*. Access Excellence. <http://www.accessexcellence.org/LC/TL/buchanan/actively.html>

Caglioti, C. *Preparation for an American University Program*. Southampton College of Long Island University. <http://www.southampton.liunet.edu/academic/pau/course/webesl.htm>

Dictionary.com. Copyright © 2005, Lexico Publishing Group, LLC. <http://dictionary.reference.com/>

Lanier, Judy. *The Monotillation of Traxoline*.

Latin Phrase information about **in situ**. © 1999-2005 by GuruNet. All rights reserved. <http://www.answers.com/topic/in-situ?method=5&linktext=In%20Situ>

Merriam Webster's Collegiate Dictionary, Eleventh Edition. Merriam –Webster, Incorporated: Springfield, MA, 2003.